Introduction to Geology

Geology is the study of Earth's history as revealed in its rocks, sediments, structures and the forces affecting them. Our planet is approximately 4.5 billion years old. Its face and interior are constantly changing, and represent only the most recent phase of terrestrial transformation. Geology deals with these changes.

As an introduction, we'll work from general to specific: Geologists agree that the Earth is composed of distinct layers; even as laymen, we can identify common geological structures and the forces affecting them; we can also evaluate the characteristics of geology's most immediate elements- rocks. Finally, a review of the geological timeline might give everything some perspective.

Inside the Earth

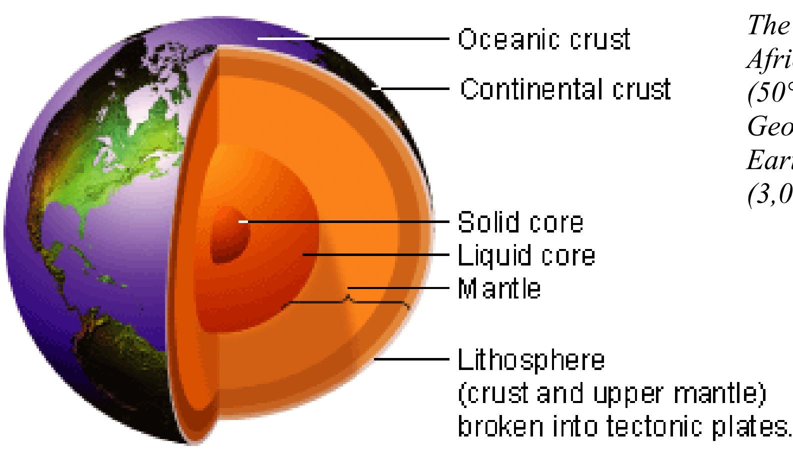
Geologists understand the Earth as a series of layers emanating from the planet's center to its outermost shell. These layers are divided into three primary zones: the core, the mantle and the crust. Amid each zone are further divisions.

- The **core** is two layers combined:
  The **inner core** is solid and the **outer core** is molten. Both are rich in hot, heavy metals, but the shifting outer core generates Earth's magnetic field.

- The **mantle** is two layers:
  The deeper, molten **asthenoshpere**, and the thinner, solid **lithosphere**. Convection currents (from heat in the core) permeate the mantle and influence its movement.

- The Earth's **crust** is also two layers:
  The **continental crust** is expressed as land, while **oceanic crust** is the thinner, denser material that composes our sea-floors.

Of the 3-zones, scientists have only been able to study the crust first-hand. The prime reasons are complications related to depth, heat and pressure. For instance, at it's deepest- under some mountains- the crust extends 22-miles below ground. The mantle begins at that point and extends another 100-miles to the core's periphery.



The world's deepest mineshaft is in South Africa. Temperatures there reach 122°F (50°C), and that's still within the crust. Geologists estimate that temperatures at the Earth's core are probably around 5,400°F (3,000°C).

Processes & Surface Displays

Making Mountains- Mountains are some of geology's most breathtaking formations. They are the crust-level result of activity within the Earth. As traceable, contiguous lines they are called **ranges**. Parallel ranges connected by plateaus are considered **chains**, and related chains are known as **systems**.

On any scale -massive to minute- physical changes resulting from stresses within the Earth is called **deformation**. The varying results of deformation depend on the composition of the effected materials, the rate and the strength of the applied force.

- *Rising & Sinking*
  The gentle rising or falling of the crust is called **warping**. Although the action isn't always gentle, it usually creates **block** mountains, typified by their flat, steep-sides. Enough sinking often creates seas. Sinking action formed the Mediterranean Sea.

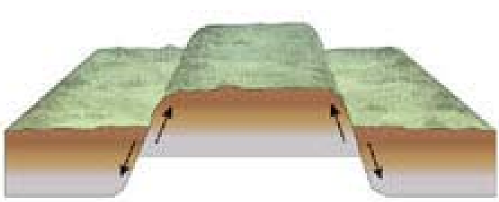
- *Tilting & Folding*
  Tension and compression in the crust deform sediment layers. Pressure, temperature, strain-rate, and the composition of the effected rocks determines whether the **deformation** will be tilting or folding. In either case mountains are thrust upwards by the activity.

  - There are six fold types:
    monocline, anticline, pericline, syncline, overfold, and nappe.

- *Breaking*
  Pressure and tension in the Earth's crust is sometimes relieved by splits in parts of the crust that are closer to the surface. These splits are **joints** and **faults**. Unlike joints, faults are characterized by movement in adjacent rock masses.

  Faults form along a line of weakness called the **fault plane**. They represent the easiest locale for the stresses within the Earth to be released as surface movement. That surface movement is an **earthquake**.

  - There are six fault types:
    a normal fault, a reverse fault, a tear fault, a graben, a horst, and a tilt block



horst

graben

Reshaping the Land- In geology two unstoppable forces are always at work: those which build-up the land, and those which wear-down the land. Once land-masses are built, less dramatic processes rework their surfaces, alter their constituent materials and change their shapes.

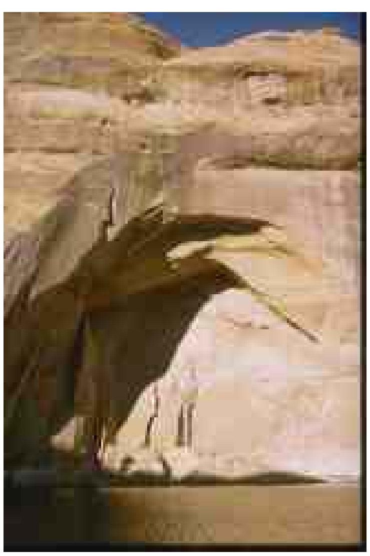
Erosion is the process that occurs via wind, water or ice and transports particles from one location to another. It can level mountains and sculpt the land with deep, wide cuts. We can describe erosion with three general terms: weathering, gravity, and transportation.

- *Weathering*
  Physical or **mechanical weathering** destroys rock without changing its chemical (elemental) structure. Cold and dry climates promote this activity the best.

  Chemical weathering destroys the elemental structure of a rock. The process is usually induced by rainwater and its ingredients, usually carbon dioxide.

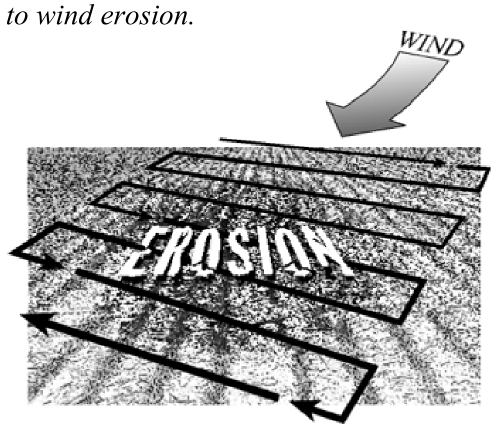
- *Mass Wasting (Gravity)*
  When gravity pulls soil or rock downhill mass wasting is taking place. It can happen slowly, as **soil creep** or **earth flow**, bought-on by saturated soils. Or it might happen rapidly, as a **landslide** or **rockslide** triggered by an earthquake or heavy rains.

- *Transportation*
  Material relocation has four techniques: **wave action**, like where the sea meets the land and reshapes it; **ice** and **glacier** transport, which is the most powerful of erosive forces; **wind**, the slowest but farthest reaching of the four; and **stream flow**, effective as a function of its volume and velocity.



Lake Powell, AZ. Arches and bridges created by wind & water erosion

In the 1930s, after generations of failing to return organic matter to the soil and years of raising the same crops, farmers in America's prairie land lost tons of top soil to wind erosion.



Three Classes of Rock

Rocks are classified by how they formed. Geology distinguishes three formation methods and each method represents a different class of rock. Besides describing smaller, more familiar materials, these classes also describe larger geological structures.

- *Igneous*
  Igneous rocks are formed by fire; what they have in common is that they begin as molten rock. Above ground, molten rock is called **magma**. Below ground its considered **lava**. How igneous rocks cool from their molten condition distinguishes them into subclasses.

  Intrusive igneous rocks cool slowly. They're typified by coarse crystal textures. They produce batholiths, sills, and dikes.
  ✓ Examples: *granite, diorite, gabbro*

  Extrusive igneous rocks cool quickly and are characterized by fine and glassy textures. Volcanic structures are commonly extrusive igneous formations: ash, cinder and lava cones; basalt plateaus and lava plains; and volcanic plugs.
  ✓ Examples: *rhyolite, obsidian, basalt, pumice, volcanic ash & breccia*

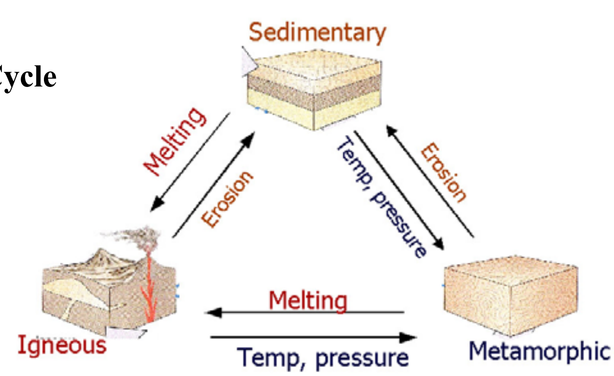
- *Sedimentary*
  Sedimentary rocks are formed by materials deposited through erosion. **Fossils** are typically found in sedimentary rock.

  Clastic rocks form when eroded materials from pre-existing rocks settle together and create a new rock. **Chemical/organic** rocks form from chemical precipitation or the remains of plant/animal matter.

  Alluvial fans, glaciers, rivers, dunes, lakes, estuaries, and reefs are all sedimentary formations.
  ✓ Examples: *rhyolite, obsidian, basalt, pumice, volcanic ash & breccia*

- *Metamorphic*
  Metamorphic rocks are formed from igneous or sedimentary rocks that are exposed to heat, pressure, chemical, gas or fluid activity. The greater any of these influences, the greater the changes that take place in the rock
  ✓ Examples: *gneiss, slate, quartzite, and marble*

The Geologic Rock Cycle



The Geologic Timeline

From Earth's formation to present day represents approximately 4.5 billion years of transformation. This is a massive, and nearly incomprehensible span. Visualizing this sort of chronology requires willful and persistent imagination. *(mya = millions of years ago)*

<table>
<tr><th>Era</th><th>Period</th><th>Epoch</th><th>Material Activity</th></tr>
<tr><td rowspan="4">Cenozoic</td><td>Quaternary
1.8 mya-present</td><td>Pleistocene</td><td>Continental - glacial, river and stream, wind, lake, swamp, and colluvial deposits and soils.</td></tr>
<tr><td rowspan="3">Tertiary
65-1.8 mya</td><td>Pliocene</td><td rowspan="3">Continental – gravel river deposits.
Deltaic - mostly sand, some silt
Marine - mostly clay, some sand</td></tr>
<tr><td>Eocene</td></tr>
<tr><td>Paleocene</td></tr>
<tr><td>Mesozoic</td><td>Cretaceous
144 - 65 mya</td><td>Gulfian</td><td>Deltaic and near shore marine –
sand, some silt and clay, locally lignitic</td></tr>
<tr><td rowspan="20">Paleozoic
"Age of Visible Life"</td><td rowspan="5">Pennsylvanian
323-290 mya</td><td>Virgilian</td><td rowspan="5">Marine, Deltaic, Continental -
cyclical deposits, mostly shale, sandstone, and siltstone with some limestone, coal clay black sheety shale, sandstone dominant in lower part, shale above, coal most prominent in middle part, limestone in upper part</td></tr>
<tr><td>Missourian</td></tr>
<tr><td>Desmoinesian</td></tr>
<tr><td>Atokan</td></tr>
<tr><td>Morrowan</td></tr>
<tr><td rowspan="3">Mississippian
354-323 mya</td><td>Chesterian</td><td rowspan="3">Marine, continental-
cyclical deposits of limestone, sandstone, thick coal-producing carbon layers, remains of swampy tropical forests drowned by shallow seas, insects and early reptiles</td></tr>
<tr><td>Valmeyeran</td></tr>
<tr><td>Kinderhookian</td></tr>
<tr><td rowspan="3">Devonian
408-354 mya</td><td>Upper</td><td rowspan="3">Marine-
widespread coral reefs, rich oil deposits, fresh water fishes and first amphibians</td></tr>
<tr><td>Middle</td></tr>
<tr><td>Lower</td></tr>
<tr><td rowspan="3">Silurian
440-408 mya</td><td>Cayugan</td><td rowspan="3">Marine-
melting ice sheets, oldest land plants and animals</td></tr>
<tr><td>Niagaran</td></tr>
<tr><td>Alexandrian</td></tr>
<tr><td rowspan="3">Ordovician
505-440 mya</td><td>Cincinnatian</td><td rowspan="3">Marine-
ice sheets, salty seas, colonial organisms called graptolites, early jawless fishes</td></tr>
<tr><td>Champlainian</td></tr>
<tr><td>Canadian</td></tr>
<tr><td>Cambrian
590-505 mya</td><td>Croixan</td><td>Marine-
sandstone, dolomite, shale
first abundant animals with skeletons and shells such as trilobites, generally warmer than today</td></tr>
<tr><td colspan="3">Protozoic - "Age of Former Life"
2,500 to 590 mya</td><td>first large continents, shallow seas, ozone layer formed, soft corals, jellyfish, worms</td></tr>
<tr><td colspan="3">Archean - "Ancient Age"
4,000 to 2,500 mya</td><td>continental rock, an ocean, an atmosphere, bacteria and blue-green algae</td></tr>
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